(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
28 November 2002 (28.11.2002)

PCT

(10) International Publication Number
WO 02/094602 A1

(51) International Patent Classification[7]: B60K 41/28, F16H 61/02

(21) International Application Number: PCT/SE02/00842

(22) International Filing Date: 29 April 2002 (29.04.2002)

(25) Filing Language: Swedish

(26) Publication Language: English

(30) Priority Data:
0101791-2 18 May 2001 (18.05.2001) SE

(71) Applicant *(for all designated States except US)*: VOLVO CONSTRUCTION EQUIPMENT COMPONENTS AB [SE/SE]; S-631 85 Eskilstuna (SE).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: CARLSSON, Sven-Åke [SE/SE]; Klaraborgsvägen 7, S-632 39 Eskilstuna (SE).

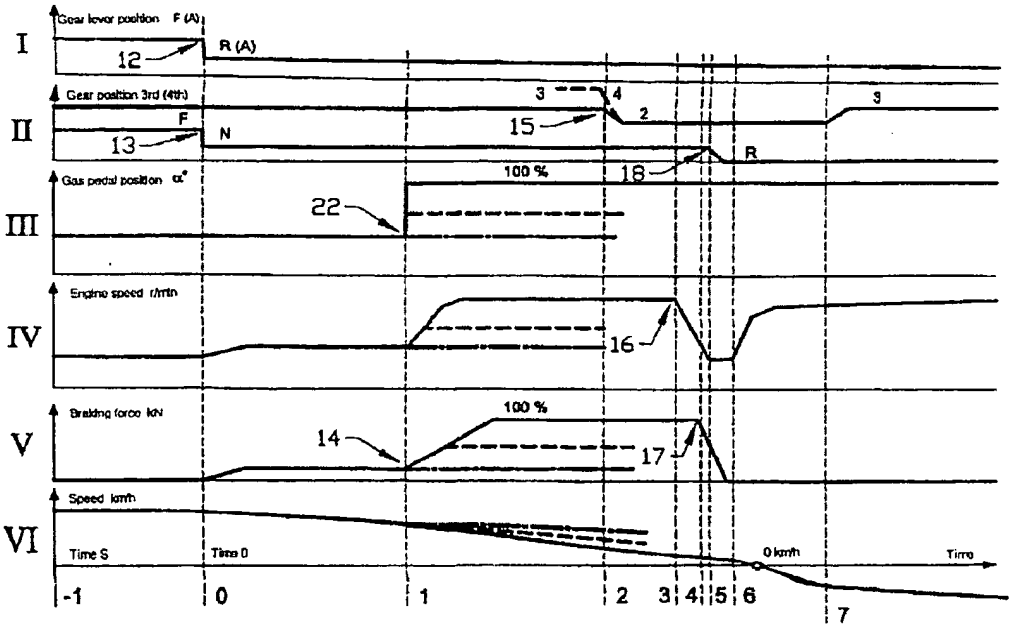
(74) Agent: FRÖHLING, Werner; Volvo Technological Development Corporation, Corporate Patents, CTP, 06820, Sven Hultins Gata 9C, S-412 88 Göteborg (SE).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent

[Continued on next page]

(54) Title: A METHOD FOR REVERSING THE DRIVING DIRECTION



(57) Abstract: The invention concerns a method for reversing the driving direction of a vehicle in motion, in which a movement of a gear selector to a position that indicates the new intended driving direction is detected (12), and after the gear selector has assumed the new driving direction position, the vehicle's driving brakes are applied (14) depending upon the depression of the vehicle's gas pedal.

WO 02/094602 A1

(BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Published:

— *with international search report*

A method for reversing the driving direction

TECHNICAL FIELD AND BACKGROUND ART

The present invention relates to a method for reversing the driving direction of a vehicle in motion, in which a movement of a gear selector to a position that indicates the new intended driving direction is detected. By reversing is meant changing the direction of movement to the opposite direction from the original direction. Such a reversing method is carried out frequently during the operation of a wheel loader. The wheel loader is driven forwards and backwards short distances during loading (which is a large part of its operating time). The vehicle is driven forwards, braked to a stop, driven backwards, braked to a stop, driven forwards again, etc.

As claimed in known technology, a forward and reverse gear is arranged before the gear box. In addition, a hydrodynamic torque converter is arranged between the engine and the forward and reverse gear. The torque converter is used to brake the vehicle when reversing the driving direction. With such reversing of the driving direction (for example, from forwards to backwards) the vehicle does not need to be stopped in order for reverse gear to be selected.

As claimed in one example of the method for reversing the driving direction, the reverse gear is selected by the driver using the gear selector when he wants to start to brake. The turbine wheel shaft of the torque converter is then connected to the drive wheel via the gearbox in such a way that the direction of rotation of the turbine wheel is reversed. This takes place relatively instantaneously via two disc clutches in the forward and reverse gear. The turbine wheel then starts to rotate in the opposite direction relative to the torque converter's impeller which is in direct connection with the engine, the driver being able to control the engine speed by means of the vehicle's gas pedal. This means that the turbine wheel and thereby the vehicle are slowed down. With increased gas supply, the impeller is driven with greater torque and a stronger braking is achieved. In other words, the braking force depends upon the speed of the torque converter's impeller relative to the speed of the turbine shaft. The braking force is not proportional to the engine speed, but is a function of the performance of the torque converter.

With continued gas supply, the vehicle is braked to a stop, after which the direction of the vehicle is reversed. The only gear operation the driver carries out is thus to select reverse gear and thereafter the reversing procedure is taken care of by the driver regulating the gas supply to the engine via the gas pedal.

As claimed in a preferred further development, the vehicle's gearbox is disconnected from the vehicle's engine when the gear selector has been moved to the new driving direction position. The engine can then be used at full power for another purpose, such as raising a load using the vehicle's bucket or forks, without this affecting the braking capability.

BRIEF DESCRIPTION OF DRAWINGS

The invention will be described in greater detail in the following, with reference to the embodiments that are shown in the attached drawings, in which

Figure 1 illustrates schematically an example of a vehicle's transmission for implementing the reversing method,

Figure 2 shows six graphs of various parameters as a function of the time for a method for reversing the vehicle's driving direction, and

Figure 3 shows schematically an arrangement for controlling the reversing method.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Figure 1 illustrates schematically an example of a vehicle's transmission for carrying out the reversing method as claimed in the invention. By reversing is meant changing the direction of movement to the opposite direction from the original direction. Such a reversing method is carried out frequently during the operation of a wheel loader.

Figure 1 shows a combustion engine 1, in the form of a diesel engine, an automatic gearbox 2 and a hydrodynamic torque converter 4. The gearbox 2 comprises a forward and reverse gear 3. Figure 1 also shows a pump 5 for the vehicle's lifting hydraulics, which pump (like the torque converter) is driven by an outgoing shaft 6 from the engine 1. An outgoing shaft 7 from the gearbox 2 leads to a differential gear 27 on a wheel axle 8, on which the vehicle's driving wheels 9 are arranged. A driving brake 10 is arranged on each of the wheels 9.

The gearbox consists of an electronically controlled automatic gearbox of the power-shift type.

Figure 2 shows six graphs of various parameters as a function of the time for a first embodiment of the reversing method. The uppermost first graph I in Figure 2 shows

The invention will be described below for reversing the driving direction of a wheel loader. This is to be regarded as a preferred, but in no way limiting application of the invention. The reversing method is also applicable to other types of work machines, such as a frame-steered vehicle, a so-called dumper, and other types of vehicle, such as industrial trucks.

DISCLOSURE OF INVENTION

An object of the invention is to achieve a method for reversing the driving direction, which makes possible consumption of less energy by the vehicle's engine in comparison to previously known technology.

This object is achieved by the vehicle's driving brakes being applied depending upon the depression of the vehicle's gas pedal, after the gear selector has assumed the new driving direction position. In other words, the vehicle is braked by its driving brakes and not by the torque converter during the said reversing procedure. By this means, it is not necessary to use the engine for braking, which results in a reduction in fuel consumption. The level of application of the driving brakes preferably increases with increased depression of the position of the vehicle's gas pedal.

In addition, there is a reduced need to cool the vehicle's engine in comparison to previous technology, as as claimed in previous technology it was necessary to conduct away the heat generated in the torque converter during the braking via the vehicle's cooling system.

In addition, the braking becomes predictable, as the depression of the gas pedal by the driver controls the retardation. This means that the same retardation is achieved irrespective of the gear position.

In addition, the engine power can be used for a purpose other than for braking, such as raising a scoop load, which other application accordingly does not affect the braking capability.

As claimed in a preferred embodiment, the speed of the vehicle's engine increases with increased depression of the gas pedal. This makes it possible for the driver to use the same driving strategy as as claimed in previous technology. In other words, the higher the engine speed, the greater the braking power.

the position of a gear selector or gear lever (not shown). The second graph II shows the gear positions in the gearbox 2. The third graph III shows the position of the gas pedal (not shown). The fourth graph IV shows the engine speed. The fifth graph V shows the braking force. The sixth graph VI shows the speed of the vehicle.

Figure 3 shows, in addition, an arrangement 11 for controlling the reversing method. The arrangement comprises a first control unit 26 (or ECU, Electrical Control Unit) with software for controlling the method.

The procedure begins by the wheel loader being driven forwards with a first gear position selected and with a first speed. As claimed in the example shown, third gear is selected and the vehicle is moving at a speed of, for example, 15 km/h. The driver now wants to change the driving direction from forwards to backwards, initially with second gear selected for the driving backwards. He therefore moves the gear selector to a position that indicates the new intended backwards driving direction and second gear. The movement of the gear selector to the new position is detected 12 by a first detector 25 connected to the control unit 26.

Upon movement of the gear lever or after detection of the new gear position, the vehicle's main gearbox 28 is disconnected 13 from the vehicle's engine 1 via the forward and reverse gear 3. The engine power can now be used in its entirety to supply hydraulic functions via the pump 5 and other consumers of power in the vehicle. The engine speed and the braking force are now increased slightly, while at the same time the vehicle's speed is reduced, see the graphs IV-VI after the time zero.

For braking the vehicle, the driver depresses 22 the gas pedal, which controls the application 14 of the vehicle's driving brakes 10, that is the wheel brakes. The position of the gas pedal is detected for this purpose by a second detector 24. More specifically, the level of application of the driving brakes is controlled as a function of the position of the vehicle's gas pedal. The vehicle's retardation can hereby be controlled as required, for example linearly or non-linearly.

The arrangement 11 comprises a second control unit 29, see Figure 3, for controlling the speed of the engine 1. The second control unit 29 is functionally connected to the first control unit 26 and obtains information from this concerning the desired engine speed. This desired engine speed is in turn controlled by the degree of

depression of the gas pedal. This means that the driver can use the driving strategy: the higher the engine speed, the greater the braking force.

The engine speed is thus increased with increased depression of the gas pedal and the speed of the vehicle is reduced. The broken lines in Figure 2 show the engine speed, the braking force and the speed of the vehicle in the event of a reduced depression of the gas pedal and the chain-dotted lines show the engine speed, the braking force and the speed of the vehicle when the gas pedal is not operated.

The engine speed is detected via a sensor 30 and the speed of a turbine in the torque converter 4 is detected via an additional sensor 31. These sensors are connected to the first control unit 26. On the basis of these detected values, a soft application of the driving brakes 10 can be carried out.

A third detector 32 detects depression of the vehicle's brake pedal. The third detector 32 is connected to the control unit 26, whereby the braking force generated by the depression of the gas pedal can be intensified by depression of the brake pedal. In other words, the algorithm that the ECU 26 sends out to the driving brakes 10 is strengthened upon depression of the brake pedal.

After braking has commenced via the depression of the gas pedal, the ECU 26 controls a number of operations automatically depending upon the vehicle's speed:

The vehicle's speed is detected by sensors 23 in a conventional way, for example by measurement of the speed of rotation of a shaft inside the gearbox 2. After disconnection 13 of the gearbox 2, a change down 15 from third gear to second gear is carried out automatically when the speed is less than a first predetermined value. The broken line in graph II in Figure 2 shows the case with fourth gear instead of third gear, and with a change down to second gear being carried out from fourth gear.

When the vehicle's speed is less than a second predetermined value, the engine speed is automatically reduced 16 in order to give a soft connection of the reverse gear R in the forward and reverse gear 3.

When the vehicle's speed is less than a third predetermined value, the driving brakes 10 are disconnected 17 smoothly.

When the vehicle's speed is less than a fourth predetermined value that is close to zero, a soft, stepless change from forward F to reverse position R in the forward and reverse gear 3 is commenced 18. With continued gas supply, the vehicle is accelerated in the new direction (backwards). This takes place suitably at essentially the same time as the driving brakes 10 are disconnected.

In other words, the reversing procedure is controlled in accordance with a predetermined sequence after the gear selector has been moved to the position that indicates a new intended driving direction and the gas pedal has been activated.

As claimed in the preferred embodiment, the driving brakes 10 are applied as a function of the position of the gas pedal and, more specifically, linearly up to a specific value, which corresponds to the position of the gas pedal. In this way, the driver experiences the same course of events as as claimed in previous technology, that is with increased depression of the gas pedal, the vehicle is braked more. In other words, the higher the engine speed, the greater the braking force.

By means of disk clutches (friction clutches) in the forward and reverse gear, the reverse gear is selected gradually at the same time as the driving brakes 10 are gradually deactivated during the change of direction.

As an alternative or supplement to the application of the driving brakes as a function of the position of the gas pedal, the application can be carried out in accordance with a predetermined sequence.

The abovementioned control unit ECU 26 is also often called a CPU (Control Power Unit).

The term gear selector covers both a single operating device controlling both the driving direction and the gear position, and also a separate operating device controlling the driving direction and another separate operating device controlling the gear position.

The invention is not to be considered to be restricted to the abovementioned embodiments, but a number of further variants and modifications are possible within the framework of the following patent claims.

For example, the gearbox design shown in Figure 1 is only to be regarded as an example of a gearbox that can be used for carrying out the reversing method.

In addition, the two control units 26, 29 can be integrated into a single control unit.

As an alternative to a change downwards being carried out automatically when the speed is less than a first predetermined value, the changing down can be carried out instead after a certain period of time after the commencement of the braking procedure and, if required, also depending upon the degree of application of the brakes.

As an alternative to detecting the vehicle's speed as claimed in the example above and a reduction in the engine speed being carried out automatically when the vehicle's speed is less than a second predetermined value, the engine speed can be reduced instead after a certain period of time after the commencement of the braking procedure and, if required, also depending upon the degree of application of the brakes.

As an alternative to detecting the vehicle's speed and disconnecting the driving brakes when the vehicle's speed is less than a third predetermined value, the disconnection can be carried out instead after a certain period of time after the commencement of the braking procedure and, if required, also depending upon the degree of application of the brakes.

As an alternative to detecting the vehicle's speed as claimed in the example and commencing a change from forward to reverse position in the forward and reverse gear when the vehicle's speed is less than a fourth predetermined value that is close to zero, the change can be carried out instead after a certain period of time after the commencement of the braking procedure and, if required, also depending upon the degree of application of the brakes.

The invention has been described above in the case when a reversing of driving direction from forwards to backwards is being carried out, but it is of course also within the scope of the following patent claims to reverse the driving direction from backwards to forwards in a corresponding way. In addition, the example described above, with changing from third forward gear to second reverse gear is, of course, only to be regarded as an example. In other words, the method can start with a

different gear selected, such as second or fourth gear, and also end with a different gear selected, such as third or fourth gear.

CLAIMS

1. Method for reversing the driving direction of a vehicle in motion, in which a movement of a gear selector to a position that indicates the new intended driving direction is detected (12),
characterized in that
after the gear selector has assumed the new driving direction position, the vehicle's driving brakes (10) are applied (14) depending upon the depression of the vehicle's gas pedal.

2. Method as claimed in Claim 1,
characterized in that
the driving brakes (10) are applied proportionally to the position of the gas pedal.

3. Method as claimed in Claim 1 or 2,
characterized in that
the speed of the vehicle's engine (1) increases with increased depression of the gas pedal.

4. Method as claimed in any one of the preceding claims,
characterized in that
when the gear selector is moved or has been moved to the new driving direction position, the vehicle's gearbox (2) is disconnected (13) from the vehicle's engine (1).

5. Method as claimed in Claim 4,
characterized in that
after disconnection (13) of the vehicle's gearbox (2) from the vehicle's engine (1), a change (15) in the gearbox is carried out from the current gear position to a position that indicates the selected gear for driving in the new direction.

6. Method as claimed in any one of the preceding claims,
characterized in that
after application of the vehicle's driving brakes, the engine speed is reduced (16) automatically.

7. Method as claimed in any one of the preceding claims,
characterized in that

after application of the vehicle's driving brakes and when the vehicle's speed has dropped to a value close to zero, the driving brakes (10) are deactivated (17).

8. Method as claimed in Claim 7,
characterized in that
upon deactivation of the driving brakes (10), the control of these via the position of the gas pedal ceases, and instead they are deactivated (17) gradually until the speed of the vehicle is zero.

9. Method as claimed in any one of the preceding claims,
characterized in that
after application of the vehicle's driving brakes (10) and when the vehicle's speed has dropped to a value close to zero, the gearbox (2) is gradually connected (18) to the engine (1) in such a way that the vehicle is moved in the new driving direction.

10. Method as claimed in Claims 8 and 9,
characterized in that
the driving brakes (10) are gradually deactivated (17) at the same time as the said gradual connection of the gearbox (2) to the engine (1) is carried out (18).

11. Method as claimed in Claim 9 or 10,
characterized in that
the said gradual connection of the gearbox (2) is carried out (18) via disc clutches.

12. Method as claimed in any one of the preceding claims,
characterized in that
the gearbox (2) consists of an electronically controlled automatic gearbox.

13. Method as claimed in any one of the preceding claims,
characterized in that
the vehicle consists of a work machine, in particular a wheel loader.

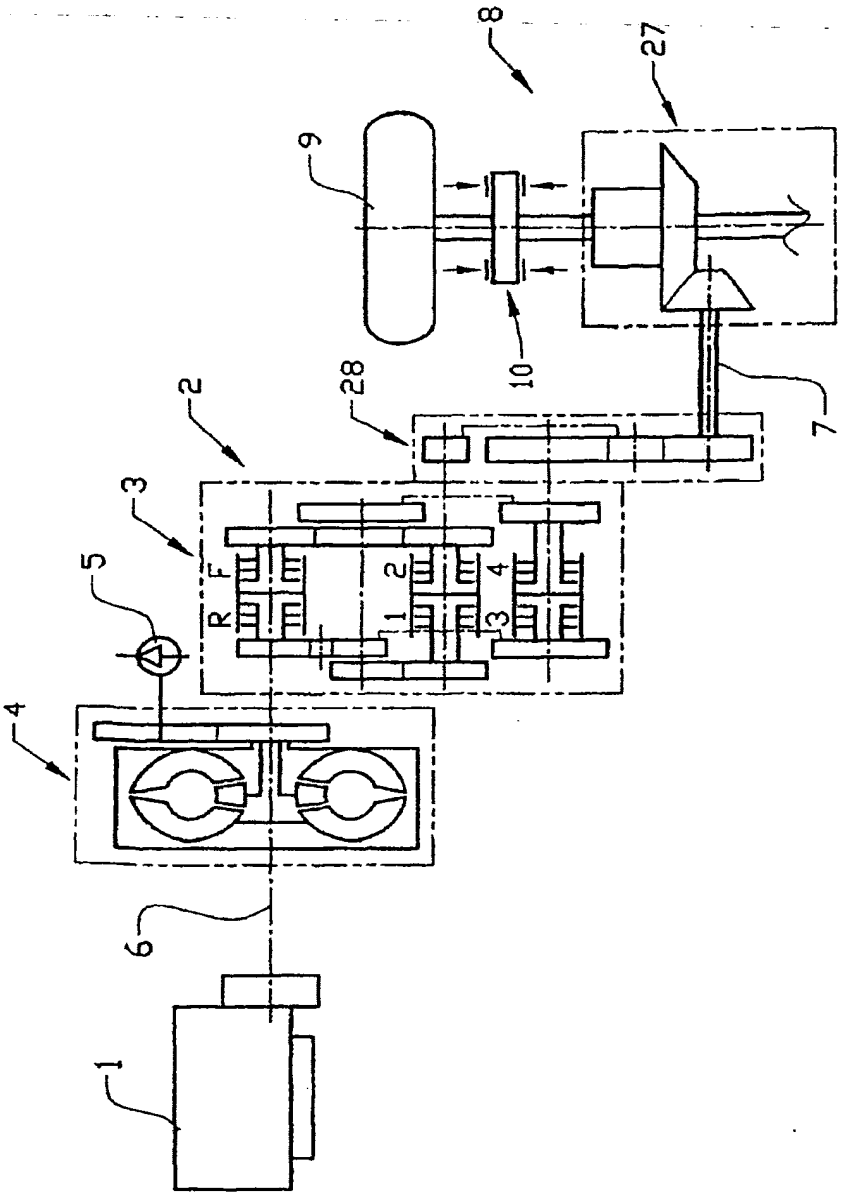


Fig.1

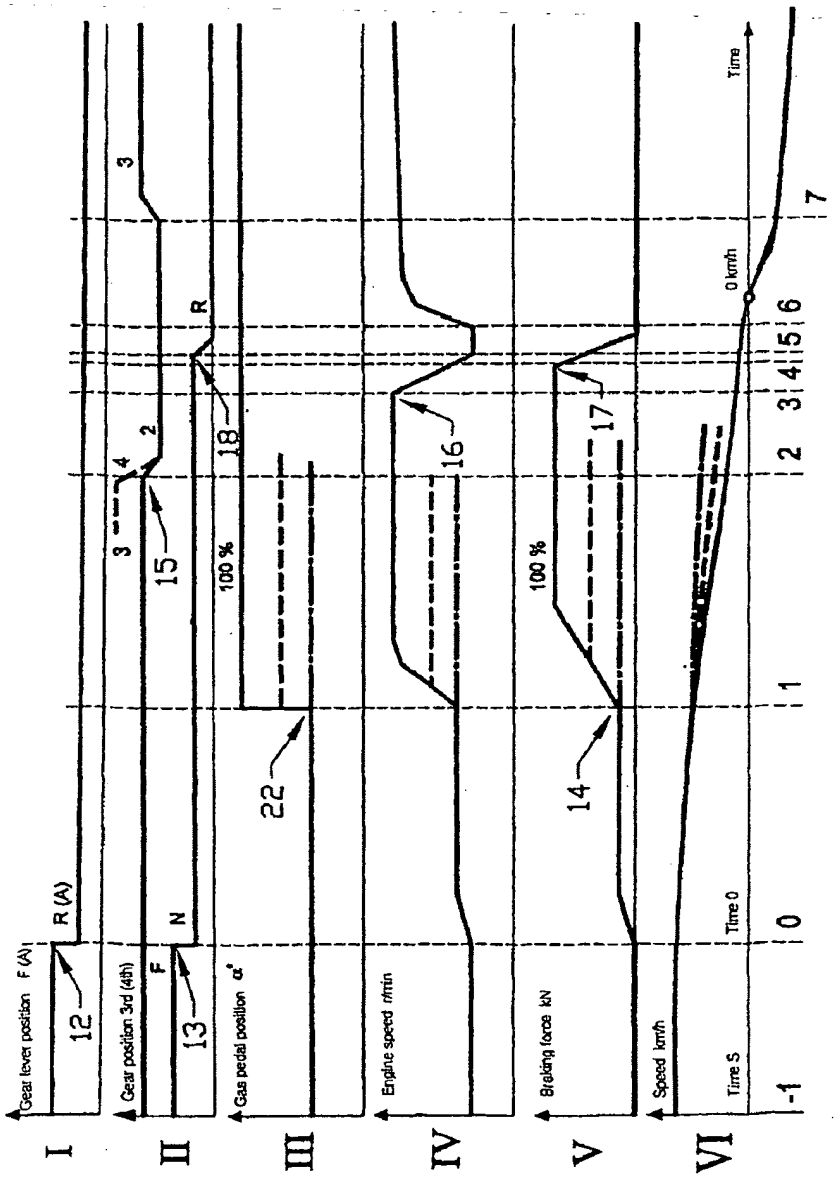

I
II
III
IV
V
VI
Gear lever position F (A)
R (A)
N
F
12
13
Gear position 3rd (4th)
3
4
2
15
R
18
Gas pedal position α°
100 %
22
Engine speed r/min
16
Braking force kN
100 %
17
14
Speed km/h
Time S
Time 0
0 km/h
Time
-1
0
1
2
3
4
5
6
7

Fig.2

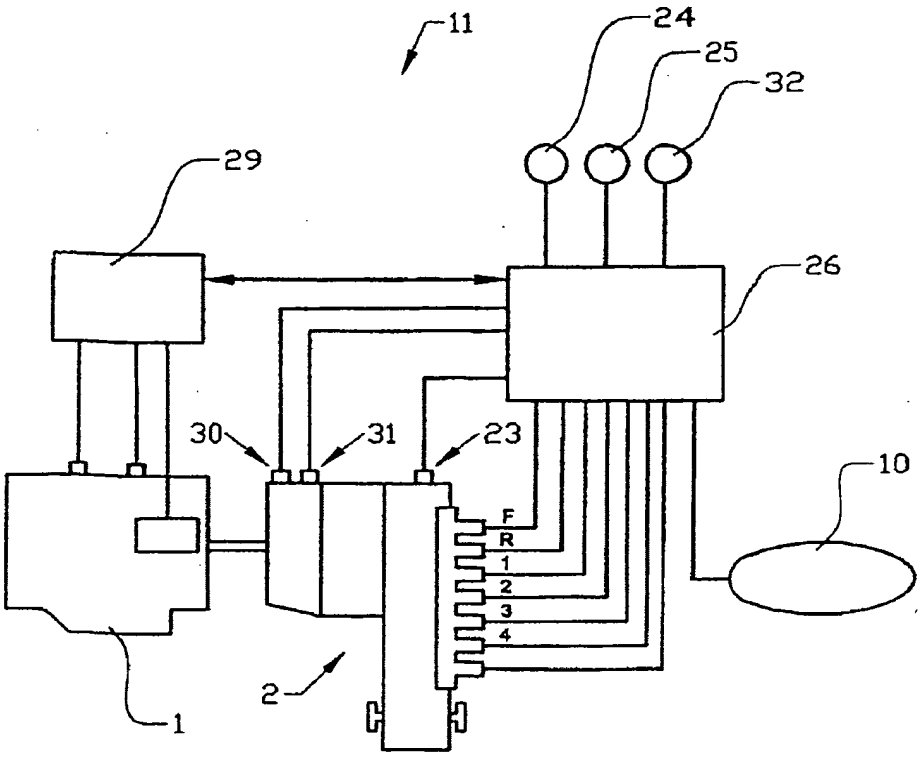


Fig.3

INTERNATIONAL SEARCH REPORT

In tional application No.
PCT/SE 02/00842

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: B60K 41/28, F16H 61/02
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: B60K, B60T, F16H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5875680 A (LORRIETTE), 2 March 1999 (02.03.99) --	1-13
A	US 4768636 A (ITO ET AL), 6 Sept 1988 (06.09.88) --	1-13
A	US 4300652 A (REDZINSKI ET AL), 17 November 1981 (17.11.81) --	1-13
A	US 3913700 A (JAMES), 21 October 1975 (21.10.75) --	1-13
A	US 3831721 A (SHORE), 27 August 1974 (27.08.74) --	1-13

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
1 July 2002	29-07-2002
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Per-Olof Warnbo / JA A Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

Information on patent family members

10/06/02

Int ational application No.
PCT/SE 02/00842

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5875680 A	02/03/99	EP 0821188 A	28/01/98
		GB 2315826 A,B	11/02/98
		GB 9615793 D	00/00/00
US 4768636 A	06/09/88	DE 3674768 D	00/00/00
		EP 0231393 A,B	12/08/87
		JP 1842342 C	12/05/94
		JP 5050439 B	29/07/93
		JP 62027296 A	05/02/87
		WO 8700489 A	29/01/87
		JP 1873763 C	26/09/94
		JP 5085380 B	07/12/93
		JP 62026133 A	04/02/87
		JP 1823477 C	10/02/94
		JP 5030653 B	10/05/93
		JP 62039334 A	20/02/87
		JP 1899849 C	27/01/95
		JP 6026946 B	13/04/94
		JP 62039333 A	20/02/87
		JP 1873766 C	26/09/94
		JP 5085381 B	07/12/93
		JP 62039335 A	20/02/87
		JP 62152923 A	07/07/87
		JP 62152929 A	07/07/87
		JP 62152932 A	07/07/87
US 4300652 A	17/11/81	NONE	
US 3913700 A	21/10/75	NONE	
US 3831721 A	27/08/74	DE 1813527 A,B,C	03/07/69
		GB 1248594 A	06/10/71
		US 3458018 A	29/07/69
		US 3540559 A	17/11/70
		US 3606906 A	21/09/71
		US 3843205 A	22/10/74
		US 3858696 A	07/01/75